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MULTI-FILTER SPECTROPHOTOMETRY SIMULATIONS

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Introduction

To complement both the multi-filter observations of quasar environments described by Craven *et al.* in these proceedings, as well as the proposed UBC 2.7m Liquid Mirror Telescope (LMT) redshift survey (Hogg *et al.* these proceedings; Gibson & Hickson 1992), we have initiated a program of *simulated multi-filter spectrophotometry.* The goal of this work, still very much in progress, is a better *quantitative* assessment of the multiband technique pioneered by Baum (1962) and Oke (1971), as a viable mechanism for obtaining useful redshift and morphological class information from large scale multi-filter surveys.

Methodology and Preliminary Results

The methodology utilized in our study is qualitatively straightforward (a full *quantitative* discussion is forthcoming - Callaghan *et al.*, in preparation): multi-filter spectrophotometric observations are simulated by adding a representative spectrum for a given galaxy's morphological class and redshift to the sky spectrum and sampling with some specified filter transmission curves. Photon noise is added and a reduced χ^2 minimization routine implemented - *i.e.*, χ^2 is computed by comparing the simulated galaxy spectra against a library of galaxy and stellar templates, the type and redshift leading to the minimum in the χ^2 distribution is assigned as that best representing the physical nature of the object.

The library of comparison templates used here consists of the seven Hubble types included in the Rocca-Volmerange & Guiderdoni (1988) atlas (RVG88), as well as the 81 stellar templates in the Gunn & Stryker (1983) catalog. Unlike previous work, which has rested solely upon comparing against local (*i.e.*, z=0) galaxy templates, we have given the user the option of using a set of templates (again based on the RVG88 atlas) which evolve as a function of lookback time based upon the standard scenarios of spectral evolution as a function of Hubble type, outlined in Guiderdoni & Rocca-Volmerange (1987). The impact of galaxy evolution upon the multi-filter technique is neglected here, but will be detailed in the later Callaghan *et al.* paper.

Our χ^2 program is in many ways akin to the cross-correlation technique so successfully employed by Tonry & Davis (1979) and Ellingson & Yee (1992, in preparation), the primary difference being the latter pair use the continuum-subtracted emission/absorption line spectra in the cross-correlation, whereas the former is optimal for intermediate-band ($\sim 100 - 400$Å) filter set observations (e.g. the 40 filters being used for the UBC 2.7m LMT redshift survey - Gibson & Hickson 1992; the 24 filters utilized in the Craven *et al.* study discussed elsewhere in this volume) for which most of the line information is lost and the continuum is the essential component in the χ^2 calculation.

A series of simulations has been completed, complementing the Craven *et al.* and UBC LMT observations. For brevity, we discuss here some of the preliminary findings from our "Craven" runs: the characteristics of this sample include low signal-to-noise ($s/n = 5.0$), intermediate redshift ($z = 0.4$), and simulated spectrophotometry through the same 24 narrow-band filters as used in the true observations.

The 24-point simulated spectral energy distributions (SEDs) were compared against the set of galaxy templates generated by simply shifting the $z = 0$ templates linearly in $\log F_\nu$ space, the magnitude of the shift necessary to minimize the χ^2 yielding the estimated redshift. In other words, the shape of the SED remains invariant with redshift (*i.e.*, no spectral evolution). Parallel to the *simulation-galaxy template* χ^2 computation, a *simulation-stellar template* χ^2 is also generated and a best assigned stellar type calculated. Late-type stars are invariably assigned as the "best-fit" stellar template, but the χ^2 is always greater than that for the galaxy assignment.

Early-type galaxy redshift assignments accurate to <2% were consistently found, as were type assignment accuracies to a fraction of a Hubble type. Later-type galaxies posed a somewhat more difficult problem in that they possess inherently flatter SEDs, making the determination of redshift more challenging. This was reflected in redshift uncertainties of ~20%, an order of magnitude or so larger than that encountered with the ellipticals. Morphological classification was still accurate to within a Hubble type. This seems reasonable given the similarities between the Sa, Sb, Sc, and Sd (Types 2, 3, 4, and 5, respectively) templates in the RVG88 atlas.

Comments and Summary

Despite apparent similarities between the late-type stellar templates and the galaxy templates, we have not encountered a situation thus far in which a galaxy has been confused with a star. Obviously this is due in part to the number of filters with which we are working (24 for the "Craven" runs). Morphological classification accurate to plus/minus a fraction of a Hubble type seems feasible, even at this low $s/n = 5.0$. Early-type galaxy redshifts accurate to 2%, or better, and late-types to ~20% are also found. Simulations run at signal-to-noise ratios of ~10 indicate that redshifts accurate to a fraction of a percent are obtainable, independent of Hubble class. Because the Craven *et al.*'s filter set has been "tuned" to the redshift of the clusters, their first filter is centered at ~4500Å. Due to this lack of "blue" filters, the all-important 4000Å break in local galaxies will be missed. Our simulations show that at low signal-to-noise ratios, it is possible to assign an anomalously high redshift to any local $z \approx 0$ galaxies that may lie in their cluster fields. Fortunately, the χ^2 is usually poor enough to make the redshift suspect. Future papers in this series will provide a more detailed quantitative error analysis.

References

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